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(54) SATURATOR AND NATURAL GAS REFORMING SYSTEM PROVIDED WITH SAME

(71) Applicant: MITSUBISHI HEAVY INDUSTRIES,

LTD., Tokyo (JP)

(72) Inventors: Masaki Iijima, Tokyo (JP); Masato

Matsuzawa, Tokyo (JP)

(73) Assignee: MITSUBISHI HEAVY INDUSTRIES,

LTD., Tokyo (JP)

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(56) References Cited

U.S. PATENT DOCUMENTS

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0351711 A2 1/1990 EP 0766050 A2 4/1997 (Continued)

OTHER PUBLICATIONS

Extended (Supplementary) European Search Report (EESR) dated May 30, 2016, issued in counterpart European Patent Application No. 13849858.9. (8 pages).

(Continued)

Primary Examiner — Kaity Handal (74) Attorney, Agent, or Firm — Westerman, Hattori, Daniels & Adrian, LLP

(57) ABSTRACT

A saturator includes: a flow path inside of which a first fluid flows; a first heat exchange unit that causes heat exchange between the first fluid and a second fluid; a second heat exchange unit that causes heat exchange between a third fluid and the first fluid after the first fluid has passed through the first heat exchange unit; a humidifying unit that adds water to the first fluid upstream from the first heat exchange unit and the second heat exchange unit; and a conveyance path that conveys the third fluid after heat exchange from the second heat exchange unit to the upstream side of the first heat exchange unit and causes said third fluid to flow into the flow path as the first fluid.

3 Claims, 5 Drawing Sheets

